Active Matter: Emerging Behavior and Statistical Description of Intrinsically Out of Equilibrium Systems

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Flocks of birds, schools of fish, or bacterial colonies constitute examples of living systems that coordinate their motion. All these systems are intrinsically out of equilibrium in the absence of any external driving. Therefore, their collective properties result as a balance between their direct interactions and the indirect coupling to the medium in which they displace, and a self-consistent dynamical approach is required to analyze their evolution. The mechanical balance that determines the states they develop spontaneously make these systems very versatile and have a natural tendency to form large scale aggregates. However, an understanding on the basic principles underlying the emergence and self-assembly on active systems poses fundamental challenges. How do the relevant entities interact with each other? Can we identify universal, generic principles associated to the main features in the self assembly and emergent behavior of intrinsically out of equilibrium systems? Are there mechanisms that can be shared by living systems and synthetic, active materials? I will consider simple statistical models to address fundamental questions and will analyze the implications the generic self-propulsion has in the emergence of structures in model suspensions. I will discuss the potential of schematic models to address fundamental questions that still remain open, such as the connection of the effective phase diagram and pressure with effective equilibrium concepts. I will consider different mechanisms, such as swimming or heterogeneous catalysis, that lead to spontaneous self-organization in the absence of external driving for a variety of active suspensions. Such a comparison will help to discern between specific ingredients and general features determining the emergent properties of active matter.

References:

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